

Economics of Contracting Public Project

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Preface

Without attributing them to any mistakes made in this thesis, some important and key ideas of the thesis are the contribution of the following persons I would like to acknowledge.

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Abstract

In this paper I consider a politician, an agent to the society, who wants to construct a dam that benefits the society. Due to various reasons such as lack of knowledge or time to construct and coordinate the construction work of the dam, the politician delegates these activities to its employee, a bureaucrat. The bureaucrat herself delegates the construction work of the dam to a contractor. The politician allocates a fixed budget to the bureaucrat so as to maximize the expected values the dam gives to the society. Given the budget, the bureaucrat designs an incentive feasible menu of contract to the contractor. The bureaucrat's contract specifies the quality of the dam constructed and the contingent transfer to the contractor. Satisfying the incentives and participation constraints of the contractor, the bureaucrat maximizes the expected value of the dam and the excess budget. The excess budget to the bureaucrat is the difference between the budget allocated to her and the contingent transfer she makes to the contractor. The bureaucrat values an excess budget by attaching a weight. The bureaucrat attaches larger weight to the excess budget values it more than those attach a lower weight. In order to judge the expected value of the dam under the contract offered by the bureaucrat, I choose the standard second best contract as the benchmark. Comparing the contract offered by the bureaucrat to the benchmark, I show that the bureaucrat offers a contract that provides a better expected value of the dam to the society than the benchmark contract. Even though the bureaucrat offers a better contract than the benchmark, the objective she involves in maximizing excess budget creates a problem for the politician and the society. Thus, I show that direct control by the politician can decrease the weight the bureaucrat attaches to the excess budget and provides a better expected value of the dam to the society. I also extend the model to a case in which the Politician's objective function sets to internalize the pollution cost due to the construction of the dam so as to attain the socially minimum and efficient level of pollution. Assuming that the objective of the bureaucrat is not set in such way that she internalizes the pollution cost arises from the construction of the dam, I show that centralized contract by the politician can solve this difference in objectives between the politician and the bureaucrat and helps the politician to control the bureaucrat.

1 Introduction

Multitudes of market failures including underdevelopment and poverty have been among the justifications for governments to take activist role in an economy. These activities include building schools and training workers, which are often undertaken through delegation. Delegation of public services either to private organization or bureaucrat (government employee) is a common phenomenon. These services often fail due to many problems. One of these problems is the fact that the services are delivered by people who have their own interests that may not be compatible with public interest. Most importantly, the incentives and constraints that bureaucrat or private organization faces may not result in decisions that expand social welfare. As a result, government rules and regulations as well as public programs or services may not be implemented in the way that their advocates want them to be. In consequence, public interventions may not have the impact that they are intended to have.

Over the past few decades, a lot has been studied about why bureaucrats behave the way they do. Much of these insights have come from the application of “economic” or “public choice” models to bureaucratic institutions. These models of bureaucratic behavior explicitly or implicitly assume that individuals are the only actor and decision maker. Individuals such as bureaucrats recognize their alternatives, anticipate potential outcomes, and rationally attempt to maximize their well-being in the face of incentives and constraints.

To maximize their well-being, bureaucrats have informational advantage over the societies. Since this information is scarce and costly to obtain, the ability of the societies and their representatives to monitor and control bureaucracy is often limited. Thus, bureaucrats behave this way not because they are bad, rather they are rational actors. Benson (1995) argued that bureaucrats are not bad people, after all. They are very good people who choose their jobs in part because they see “important” issues that they feel must be addressed. Breton and Wintrobe (1982) argue that one need not assume Machiavellian behavior, deceit or dishonesty on the part of bureaucracy to understand bureaucratic inefficiency. This is because in all likelihood they pursue their own interest like every one else though it might be veiled in the self perception of dedication and altruism.

Niskanen (1968; 1971) assumed that bureaucrats in public office could be characterized as budget maximizers. For such budget maximizing objective to matter, bureaucrat must have the discretion and power to pursue its own interests.

Bureaucrat maximizes budget when there is uncertainty. Mueller (1989) explained that “uncertainty creates the potential to exercise power; information provides the capacity to do so.” If there is no uncertainty (if the oversight sponsor has full knowledge of the working of bureaucrat), then bureaucrats can have no discretions and power to pursue their personal objectives. However, the uncertainty and measurement problem that commonly exist in the sponsor-bureaucrat relationship creates a major monitoring problem for the sponsor. Niskanen (1971) recognized measurement problem create a significant monitoring problem for the sponsor. Tullock (1965), Breton and Wintorbe (1982) are also recognized the same problem.

Migue and Belanger (1974) explained that budget maximization limits the range of utility maximizing efforts. They proposed that, bureaucrat seeks discretion reflected by budgets with excess revenues over actual costs. These excess revenues are referred to as a “discretionary budget” or “organizational slack.” As Moe (1997) argued, this is equivalent to the personal income of the bureaucrat. Discretionary budgets may be the sources of many of bureaucratic perquisites, for instance, and perhaps for some of the bureaucrat’s income as well. Therefore, uncertainties embodied in the bureaucrat personal interest (mostly different from the sponsor’s interest) create a hug information gap between the sponsor and the bureaucrat. Thus, the sponsor should have a mechanism that enables it to get as much information as possible from the bureaucrat.

In order to reduce the information gap between the sponsor and the bureau, the sponsor should employ the “principal agent model.” The principal agent model was initially developed to investigate more general questions of incomplete information and risk sharing (Ross, 1973; Spence and Zeckhauser, 1971) and it has become a major analytical tool in the general literature on information economics. Later on, its relevance for organizational analysis was quickly recognized, and applicability to the central issues of organizational theory is growing (Jensen; 1983). The principal agent model is an analytic expression of the agency relationship in which one party, the principal, consider entering in to a contractual agreement with another, the agent, in the expectation that the agent will subsequently choose action that provides outcomes desired by the principal.

The principal may seek out an agent for various reasons. Often it may lack specialized knowledge or legal certification that the agent possesses. Here, we raise the principal agent model as a means in which the principal designs an incentive to the agent and gets as much information as possible about his true type (or simply as means to control the agent).

I consider control in bureaucracy with three layers hierarchy: the politician, the bureaucrat, and the contractor. Several papers in economics and political science literature have studied control in bureaucracy and most of them are focus on incentives schemes offered to the agent in the standard two - level hierarchy with a principal and an agent. Exceptions are Banerjee (1997), Khalil and Kim (2011) and Prendergast (2003). Banerjee and Prendergast consider a situation where the bureaucrat, on behalf of the government, designs resource allocation scheme for the consumers who have private information about their types and show how these scheme are distorted or result in inefficiency. Khalil and Kim on the other hand use the same hierarchical level and arrived on the same result except that they focus on the production side.

This paper is also related to Hirari and Martimort (2011), who consider a hierarchy congress- regulator- firm. The regulator offers an incentive contract to the firm in order to limit some potential damage, so delegation letting the regulator chooses the optimal contract allows the regulator to tailor the contract to the potential damage. However, the regulator puts more weight on the firm's ability to design the contract by imposing rules (limit on transfer) on the potential contract.

In this paper I would like to consider a dam constructed by the politician for the benefit of the mass or society. Assuming that the politician may lack specialized knowledge, legal certification that the agent possesses or due to some other reasons, it delegates the detail task of mechanism designs and offering contract to the agent in this case the contractor to its delegate or the bureaucrat. As any government bureaucracies, the politician allocates a fixed budget to the bureaucrat that has to be returned if unspent. While bureaucrats are supposed to return this unspent budget to the politician, they may instead go on extravagant spending when the excess budget is available for discretionary spending. The discretionary budget allows the bureaucrat to pursue goals different from those of the politician. This goal is known as "policy drift" (Johansson; 1986).

The bureaucrat involves in policy drift goals at the expense of providing a lower expected benefit of the dam to the society. Thus, the politician should have a mechanism that helps it to

control the bureaucrat so as to reduce the excess budget to the bureaucrat. This control shifts the budget from the budget drift goal of the bureaucrat to the benefits the construction of the dam gives to the society. To have a clear idea of the effect of controlling the bureaucrat, I will begin with the case in which the politician doesn't control the bureaucrat. Once I find the optimal outcomes under the case the politician doesn't control the bureaucrat, then I extend the case in which the politician control the bureaucrat. Finally I compare the two cases and characterize the results.

Furthermore, I will go on analyzing the case when the politician gives emphasis to the pollution impact the construction of the dam causes on the societies. The key insight here is that besides maximizing the expected value of the dam, the politician objective function is also set in such a way that it minimizes the pollution cost the construction of the dam causes on the society. However, for the reason I would explain later, the bureaucrat objective function is set only to maximize the expected value of the dam and excess budget by disregarding the pollution problem arises from the construction of the dam. Thus, there are conflicting objectives between the politician and the bureaucrat. How to solve this conflicting problem? And what is its effect on the expected value of the dam? These are the questions I will address in this section.

To characterize the results; I use the second best contract offered by the private manager as the benchmark. Thus, what are the distinctive features of contract designed by bureaucrat as compared to the contract designed by private managers?, how the politician controls the budget drift goal of the bureaucrat and what is its effect on the expected benefits the dam gives to the society?, how the politician should control the bureaucrat to make her inline with its objective of minimizing the pollution impact arises from the construction of the dam.? These are the questions I focus on in this paper.

I assume that the politician represents the society or any governmental agencies that acts on behalf of the society. It provides the financial resources for the construction work of the dam; accepts the dam milestone and its completion.

The rest of the paper is organized as follows. Section 2 presents and characterizes the model with three layers (i.e, a politician, a bureaucrat, and a contractor) with their respective payoffs. In section 3 I present the contract offered by the bureaucrat to the contractor under asymmetric information about the contractor's type and analyze the results by comparing it to

the benchmark model (in fact, in the case in which the politician doesn't control the bureaucrat). In section 4 I present the politician's problem and show that it allocates a fixed budget regardless of the bureaucrat's type. In section 5 I extend section 3 to the case the politician exercise direct control on the bureaucrat. In section 6 I extend the politician objective to the case it internalizes the pollution cost arises from the construction of the dam and finally I conclude in section 7.

2 The Model

I will present a hierarchical model with three layers; a politician ("it"), a bureaucrat ("she") and a contractor or an agent ("he"). The politician is the funding authority and I assume that it has no informational capability, ability or time to run the project it funds. In the language of Aghion and Tirole (1997), the politician has formal authority but it must withdraw real authority to the bureaucrat who runs the agency. The bureaucrat her self contract with the agent or contractor who constructs the dam.

The contractor or the agent is the productive unit in the hierarchy. He constructs the dam with quality level denoted by q at a private cost $C(q) = \Theta q$, where $\Theta > 0$. The constant Θ is private information of the agent or the contractor and represents his type. It can take two values Θ_1 with probability λ_1 and Θ_2 with probability λ_2 (with $\Delta\Theta = \Theta_2 - \Theta_1 > 0$ and $\lambda_1 + \lambda_2 = 1$). The contingent transfer to the contractor of type Θ_1 or type Θ_2 is t_1 or t_2 for the quality of the dam q_1 or q_2 he constructs respectively.

In addition to the private cost, the contractor has also pollution cost $R(q) = \beta q$. The constant β is private information of the contractor with $\beta > 0$ and takes two values β_1 with probability α_1 and β_2 with probability α_2 with $(\Delta\beta = \beta_2 - \beta_1 > 0$ and $\alpha_1 + \alpha_2 = 1)$. Therefore, the total social cost of the contractor is the sum of its private cost and pollution cost i.e $T(q) = C(q) + R(q) = \Theta q + \beta q = (\Theta + \beta)q$.

I begin with the case in which the politician cares only for maximizing the expected value of the dam. Later on I will extend the model to the case in which the politician minimizes the pollution impact arises from the construction of the dam.

I use the social cost when I extend the model to the case in which the politician is an environmentalist (section 6). In the next sections, section 3, section 4 and section 5 I use the private cost of the contractor for the analysis.

2.1 The Players Payoffs

For successful delegation of the construction works of the dam to the contractor, the bureaucrat must offer the utility level at least as high as the utility level the contractor gets outside the relationship. In other words the participation constraints of the contractor should be satisfied. Normalizing the outside utility level of the contractor to 0, the participation constraint of the contractor should satisfy these conditions:

$t_i - \Theta_i q_i \geq 0$ (the case the politician doesn't concern for the environment), and

$t_i - (\Theta_i + \beta_i) q_i \geq 0$ (the case the politician concerns for the environment).

The politician is interested in the construction of the dam but does not have the time or ability to manage the contractor who runs the construction process. It delegates the task of contracting with the contractor to the bureaucrat. If the politician cannot design an incentive structure for the bureaucrat depends on her type and also doesn't exercise direct control, it allocates a fixed budget to the bureaucrat denoted by B , to maximize the expected net value of the dam,

$$P(q) = \lambda_1 V(q_1) + \lambda_2 V(q_2) - B.$$

Where, λ_1 and λ_2 are the probabilities of Θ_1 -type and Θ_2 -type contractors respectively, $V(q)$ is the expected values the quality of the dam gives to the society and it is an increasing and concave function of q .

If the politician has asymmetric information about bureaucrat's type and at the same time can designs an incentive contract to the bureaucrat with exercising direct control on her, it offers a contract to the bureaucrat by specifying different budgets and control intensities. This contract should satisfy the incentive constraint of the bureaucrat to mitigate the adverse selection problem that faces the politician.

Bureaucrat offers a contract to the agent specifying the quality (q_1 or q_2) and the contingent transfer (t_1 or t_2). The agent is a standard contractor, which has private information about his construction cost stated above. Thus, he must be given an incentive scheme to limit his information rent. The contractor has his own interest at heart and is induced to pursue the bureaucrat's interest only to the extent that the incentive structures imposed in their contract renders such behavior advantageous.

The essence of the bureaucrat's problem is the design of such an incentive structure. The difficulty of course, is that the information about the contractor's true type and input on which they are based is not only imperfect but skewed in favor of the interest of the contractor. This yields adverse selection problems that must some how mitigated. The bureaucrat must weave these integrated components in to the contractual framework in mitigating the informational asymmetry and structuring rewards, prompt the contractor to behave as the bureaucrat herself would under what ever condition might prevail.

Even though bureaucrat designs this incentive to the contractor, her personal interest which is not inline with the interest of the politician will affect the expected value of the dam. Bureaucrats gave more weight to their personal interest and a number of literatures also assumed this behavior of bureaucracy. We incorporate the interests of the bureaucrat (that compatible with the interest of the politician and that favor the bureaucrat at the cost of the interest of the politician) in setting her objective function.

On the other hand, there are also bureaucrats who get great satisfaction from "conscientious devotion to duty" given to them from the politician. The literatures have indicated that, bureaucrats rely on their self motivation and professions to resolve incentive problems. They receive most of their incentives from outside the bureaucracy mainly from organized groups of fellow practitioners and self satisfaction of doing their duty well. For instance doctors and nurses get satisfaction from curing patient, academics take satisfaction in contributing to the advancement of knowledge, teachers take pleasure from producing good students and aid workers cares about successful provision of aid.

The number of literatures pointed out the above characteristic of bureaucrat. Among them, (Rose-Ackerman; 1986) has argued that bureaucrats are professionals; they are trained in "professions", which emphasize not only technical competency but also conscientious devotion to duty". Prendergast (2007), Besley and Ghatak (2005) have pointed out that bureaucrat in public office are often intrinsically motivated to deliver goods or services they are engaged to produce. They argued that bureaucrats are organizing around a mission and bureaucrats work harder when they buy in to the mission of organization.

I consider this feature of bureaucrat and characterizing it by attaching a weight to its objective function (the objective function she involves in budget drift). Bureaucrat attaches larger weight to their budget drift objective are called "less motivated" bureaucrat and those who attaches lower weight to the budget drift objective are "motivated" bureaucrat. The

bureaucrat is motivated to deliver the expected value of the dam ($\lambda_1 V(q_1) + \lambda_2 V(q_2)$), and in addition, she also values unspent budgets ($B - \lambda_1 t_1 - \lambda_2 t_2$) to engage in policy drift. We capture this by introducing a parameter k $[0, 1]$ to represent bureaucrat relative preference for policy drift i.e her intrinsic motivation. Thus, we have the following objective function for the bureaucrat:

$$U(k, B, q) = [\lambda_1 V(q_1) + \lambda_2 V(q_2)] + k(B - \lambda_1 t_1 - \lambda_2 t_2).$$

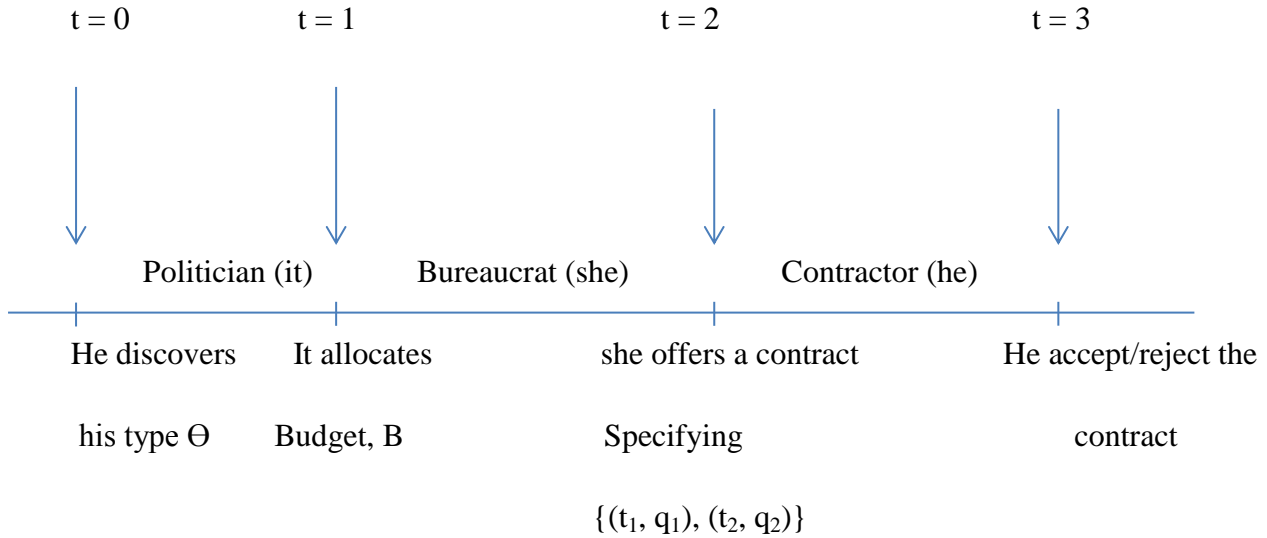
Where, $U(k, B, q)$ is the utility bureaucrat derives from the value of the dam and budget drift goals. It is an increasing and concave function of k and B . t_1 and t_2 are the contingent transfers to the efficient or the inefficient contractor respectively.

From bureaucrat's objective function we can see that if $k = 0$, the bureaucrat only cares about the expected value of the dam $[\lambda_1 V(q_1) + \lambda_2 V(q_2)]$ and she is extremely motivated. If $k = 1$, the bureaucrat cares about policy drift as much as the expected value of the dam. Thus, a higher k indicates that the bureaucrat is less motivated and has stronger preference for policy drift.

My model of bureaucracy is similar to Khalil and Kim (2011) and I use this model to analyze my cases and provide solutions to the problems at hand.

2.2 The Timing of the Game

The timing of the game is the following. First the politician allocates a fixed budget B to the bureaucrat, second the bureaucrat offers an incentive contract to the contractor specifying the expected qualities of the dam constructed (q_1 and q_2) and as well as the corresponding transfers (t_1 and t_2). We assume that the contractor learns his type before signing the contract and therefore, we have a model of adverse selection. Finally construction takes place and the appropriate transfer is given to the contractor. Where, t represents time this can be presented as,



2.3 Incentive Feasible Menu of Contract

Using the revelation principle, we impose the following incentive constraints on the bureaucrat's maximization problem:

$$t_i - \Theta_i q_i \geq t_j - \Theta_i q_j \text{ for } i, j = 1, 2, (IC_i).$$

The participation constraint,

$$t_i - \Theta_i q_i \geq 0 \text{ for } i = 1, 2 (IR_i).$$

And the budget constraint,

$$t_i \leq B \text{ for } i = 1, 2 (BG_i)$$

The first two constraints (IC_i) and (IR_i) are the standard constraints in the model of adverse selection and (BG_i) is the budget constraint that limits the transfer to the contractor by the fixed budget allocated to the bureaucrat.

2.4 The Standard Second Best Contract

I use the standard second best contract, the contract in which the politician can observe the quality of the dam constructed and directly offers contract to the contractor as the benchmark. Let call this contract the private procurement contract so as to differentiate it from the contract I deal with, contract offered by the bureaucrat. As it is stated on different books and literatures, the optimal level of the standard second best private procurement contract (PP) is given by the menu:

$$V(q_1) = \Theta_1,$$

$$t_1 = \Theta_1 q_1 + \Delta \Theta q_2,$$

$$t_2 = \Theta_2 q_2 \text{ and}$$

$$V(q_2) = \lambda_1/\lambda_2 * \Delta \Theta + \Theta_2.$$

The low cost or the efficient type of contractor constructs the efficient quality of the dam, $V(q_1) > V(q_2)$, and receives an information rent of $\Delta \Theta q_2$ while the high cost type has his quality level of the dam distorted below the efficient level and receives no information rent. This is the separating contract that sort contractors based on their types or construction costs. The efficient contractor constructs a higher quality dam than what the inefficient contractor does and this is the same as to say $q_1 > q_2$ and this again implies $t_1 > t_2$.

Having the player's payoffs and specifying the benchmark contract, next, I will see the bureaucrat's problem with a fixed budget B allocated from the politician. I analyze this case under the circumstance in which the politician doesn't exercise direct control over the bureaucrat and characterize the results by comparing to the benchmark model. Later on, I will extend the model to the case in which the politician delegate the tasks of offering contract to the contractor to its delegate, the bureaucrat, with exerting direct control on her (when the bureaucrat is not free rider).

Finally I extend the model to the case in which the politician internalizes the pollution cost arises from the construction of the dam and reduces its impact on the society. In this section I

will develop a model to see how the politician can control the bureaucrat and attains the goal of pollution reduction. Under such circumstance I assume that bureaucrat has no any concern for the pollution cost arises from the construction of the dam and doesn't include in her objective function. The reason is that internalizing the pollution cost increases the contingent transfers to the contractor and so that decreases her excess budget.

3 The Bureaucrat's Problem

If the politician doesn't exercise direct control on the bureaucrat and at the same time cannot classify the bureaucrat by her type, the politician allocates a fixed budget to the bureaucrat and so that the bureaucrat solves,

$U(k, B, q)$, such that (IC_i) , (IR_i) and (BG_i) for $i = 1, 2$, are satisfied.

Note that this problem is different from the private procurement problem, the benchmark, in two ways. First, the objective function of the bureaucrat includes two new parameters k and B and second there is also the new budget constraint (BG_i) . Solving the bureaucrat's problem, we can see below that bureaucrat offers the private procurement contract if the budget constraints are not binding and $k = 1$. If the budget constraints are binding and $k < 1$, this contract is different from the private procurement contract. Here, we will see how the motivation of the bureaucrat (k) and the budget level (B) affects the expected value of the dam as compared to the benchmark contract, the private procurement contract (PP).

3.1 The Optimal Contract

First note that (IR_2) , the individual rationality constraint of the inefficient contractor and (IC_1) , the incentive compatibility constraint of the efficient contractor are binding. If not, the bureaucrat could reduce the transfers and enjoy gains. To refrain my self from the case in which the transfer of the efficient contractor exceed the budget, I assume that $q_1 \geq q_2$ (the monotonicity constraint and let represented it by (M)); then constraint (IC_1) implies that $t_1 \geq t_2$. This again implies the budget constraint (BG_2) will satisfy if constraint (BG_1) holds. So, we can safely ignore (BG_2) from the lists of the constraints. Based on these arguments, we can present the bureaucrat problem using only the relevant constraints. The bureaucrat chooses the contract (q_1, q_2, t_1, t_2) to solve the problem,

$\max (U(k, B))$, subjected to (IR_2) , (IC_1) , (BG_1) and (M) .

Substituting t_1 and t_2 using the binding (IR_2) and (IC_1) , and setting the Lagrange we can write the Lagrange as follows:

$L = \lambda_1 V(q_1) + \lambda_2 V(q_2) + k(B - \lambda_1(\Theta_1 q_1 + \Delta \Theta q_2) - \lambda_2 \Theta_2 q_2) + \Upsilon(B - (\Theta_1 q_1 + \Delta \Theta q_2) + \mu(q_1 - q_2))$.
Where, $\Upsilon \geq 0$ and $\mu \geq 0$ are the Lagrange multipliers for (BG_1) and (M) constraints respectively. The two first order conditions with respect to the qualities are:

W.r.t q_1 : $\lambda_1 V'(q_1) - k\lambda_1 \Theta_1 - \Upsilon \Theta_1 + \mu = 0$.

w.r.t q_2 : $\lambda_2 V'(q_2) - k\lambda_1 \Delta \Theta - k\lambda_2 \Theta_2 - \Upsilon \Delta \Theta - \mu = 0$. Rearranging the results we have,

$$V'(q_1) = \Theta_1(k + \Upsilon/\lambda_1) - \mu/\lambda_1. \text{ ----- (1)}$$

$$V'(q_2) = k\Theta_2 + \Delta \Theta(\lambda_1/\lambda_2 * k + \Upsilon/\lambda_2) + \mu/\lambda_2. \text{ ---- (2)}$$

3.2 The Budget Constraint doesn't bind

From the results I presented above, we have several cases to analyze depending on whether the two constraints (BG_1) and (M) are binding or not. If the budget constraint is not binding, it implies that its multiplier $\Upsilon = 0$. Thus, (1) and (2) are reducing to,

$$V'(q_1) = k\Theta_1 - \mu/\lambda_1 \text{ and,}$$

$$V'(q_2) = \lambda_1/\lambda_2 * k * \Delta \Theta + k * \Theta_2 + \mu/\lambda_2$$

Provide that $\Theta_2 > \Theta_1$, $k\Theta_1 - \mu/\lambda_1 < \lambda_1/\lambda_2 * k * \Delta \Theta + k * \Theta_2 + \mu/\lambda_2$, which implies that $q_1 > q_2$. Again this implies $\mu = 0$. Thus, the expected optimal value of the dam under the case in which budget constrain doesn't bind is given by:

$$V'(q_1) = k\Theta_1. \text{ ----- (3)}$$

$$V'(q_2) = K(\lambda_1/\lambda_2 * \Delta \Theta + \Theta_2). \text{ ---- (4)}$$

The optimal contract (3) and (4) are very similar to the private procurement contract (PP) and are identical if $k = 1$. Its implication is that the less motivated bureaucrat, bureaucrat with highest value of k , equally values her two objectives (maximizing the expected values of the dam and the excess budget). This bureaucrat enjoys her excess budget at the cost of providing lower expected value of the dam relative to bureaucrat with lower k .

On the other hand if $k < 1$, comparing (3) and (4) with the benchmark optimum values, we can conclude that the value of the dam is larger in contract offered by the bureaucrat than contract offered by private firms. Intuitively, with unrestricted budget and the bureaucrat is intrinsically motivated, she is highly devoted to her objective of maximizing the expected value of the dam as compared to the private manager. This finding matches with what Besley and Ghatak (2005) argue. Besley and Ghatak argue that "Bureaucrats are organized around a

mission and bureaucrats work harder when they buy into the mission of the organization.” Thus, for lower k (when the bureaucrat is intrinsically motivated) and operates under unrestricted budget, the contract offered by bureaucrat has the advantage over the contract offered by private manager in providing better expected value of the dam to the society.

3.3 Budget Constrain does bind

Now we see the case when the budget constraint is binding. The binding budget is common in public bureaucracy, in which the sponsor allocated a fixed budget to the bureaucrat based on the detail tasks reported by the bureaucrat and its previous budgeting experience. If the budget constraint is binding, $B = t_1 = \Theta_1 q_1 + \Delta \Theta q_2$. In this situation, the bureaucrat offers either separating or pooling contract depending on the values of Y and k . The bureaucrat offers the separating contract if and only if the following condition satisfies:

$$Y(1/\lambda_1 * \Theta_1 - 1/\lambda_2 * \Delta \Theta) \geq k * \Delta \Theta / \lambda_2.$$

This is the condition in which the most efficient contractor constructs a higher quality dam than the inefficient one ($q_1 > q_2$) or in other word this is the condition when the monotonicity constraint should satisfy.

If $Y(1/\lambda_1 * \Theta_1 - 1/\lambda_2 * \Delta \Theta) \geq k * \Delta \Theta / \lambda_2$ doesn't satisfy, the bureaucrat prefers to offer the pooling contract. In pooling contract the bureaucrat offers the same quality i.e $q_1 = q_2 = q$. using this quality, from the binding (IC_1) we have $t_1 = t_2 = t$. which implies each type of contractor obtaining identical contract. The optimal level of transfer in pooling contract is the same as the budget level B and the optimal level of the value of the dam can easily be derived from the (IR_2). Thus, $t = B$ and $B - \Theta_2 q = 0$, where t is the transfer in pooling contract and q is the quality offers in pooling contract.

If $Y(1/\lambda_1 * \Theta_1 - 1/\lambda_2 * \Delta \Theta) \geq k * \Delta \Theta / \lambda_2$ satisfies, it is optimal for the bureaucrat to offer a separating contract with $q_1 > q_2$ and from binding (IC_1) we can find that $t_1 > t_2$. The optimal expected value of the dam and the optimal transfer for separating contract can be derived from the above first order condition by setting $\mu = 0$ (since $q_1 > q_2$). Thus, the optimal expected value of the dam and the transfers are:

$$V(q_1) = \Theta_1(k + Y/\lambda_1);$$

$$V(q_2) = \Delta \Theta(\lambda_1/\lambda_2 * k + Y/\lambda_2) + k\Theta_2;$$

$$t_1 = \Theta_1 q_1 + \Delta \Theta q_2 \text{ and}$$

$$t_2 = \Theta_2 q_2.$$

Comparing these expected optimal values with the optimal values we found in (3) and (4) (under the case of non binding budget constraint), bureaucrat provides lower expected optimal value of the dam in the case when the budget is binding. This can be shown graphically as follows:

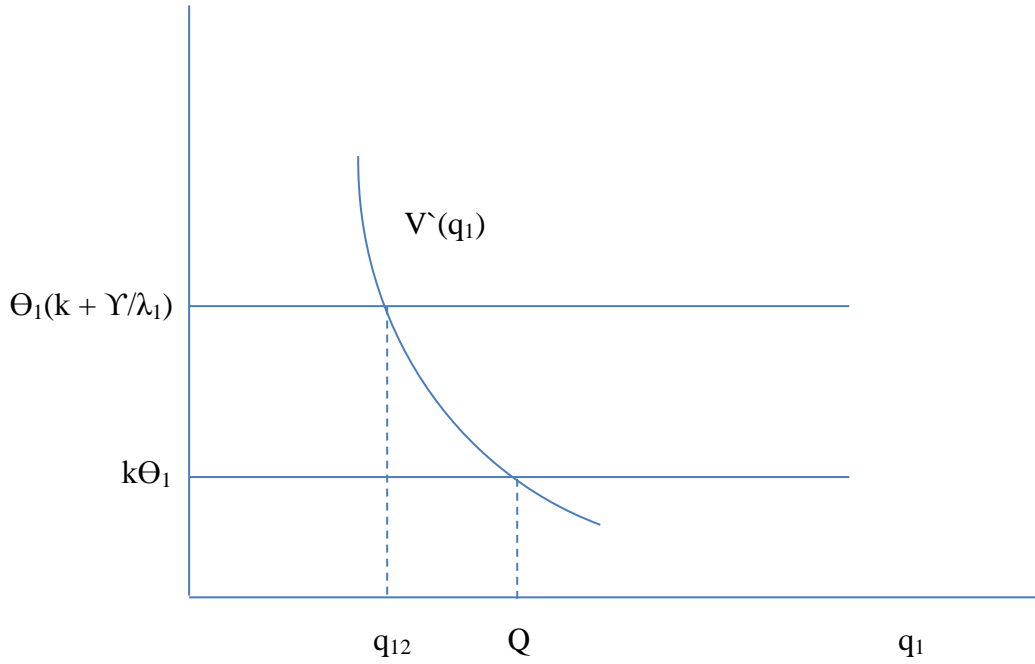


Fig. 1: The optimal qualities of the dam constructed by the efficient contractor.

In the graph shown above, we were trying to compare the qualities of the dam constructed by the efficient contractor under the two conditions (budget constrain doesn't bind and budget constrain binds). $V'(q_1)$ is the first derivative of the value function and it has a down ward sloping graph because its second derivative is less than 0 (concave value function). $k\Theta_1$ is the cost of the efficient contractor at the expected optimal value of the dam and under the condition when the budget constrain doesn't bind. $\Theta_1(k + \Upsilon/\lambda_1)$ is the cost of the efficient contractor at the expected optimal value of the dam and under the condition the budget constrain binds. It is obvious that $k\Theta_1 < \Theta_1(k + \Upsilon/\lambda_1)$ because $\Theta_1\Upsilon/\lambda_1 > 0$. This is shown on the graph by drawing $\Theta_1(k + \Upsilon/\lambda_1)$ above $k\Theta_1$.

When the budget constrain doesn't bind, the quality of the dam constructed by the efficient contractor is Q and when the budget constrain binds the quality of the dam constructed is q_{12} .

These are the qualities of the dam constructed at the expected optimum value of the dam with $Q > q_{12}$. Thus, we can conclude that bureaucrat offers a contract that provides a higher quality dam under the condition the budget constrain doesn't bind than it binds.

We can also draw similar graph for the inefficient contractor and compare the results under the two conditions (budget constrain binds and budget constrain doesn't bind). The costs of the inefficient contractor at the expected optimal value of the dam under the condition budget constrain doesn't bind and budget constrain binds respectively are $K(\lambda_1/\lambda_2 * \Delta\Theta + \Theta_2)$ and $\Delta\Theta(\lambda_1/\lambda_2 * k + \Upsilon/\lambda_2) + k\Theta_2$. Since $\Delta\Theta(\lambda_1/\lambda_2 * k + \Upsilon/\lambda_2) + k\Theta_2 > K(\lambda_1/\lambda_2 * \Delta\Theta + \Theta_2)$, the graph of the constant cost under the case the budget constrain binds is drawn above the graph of the constant cost under the case the budget constrain doesn't bind. Graphically this can be shown as,

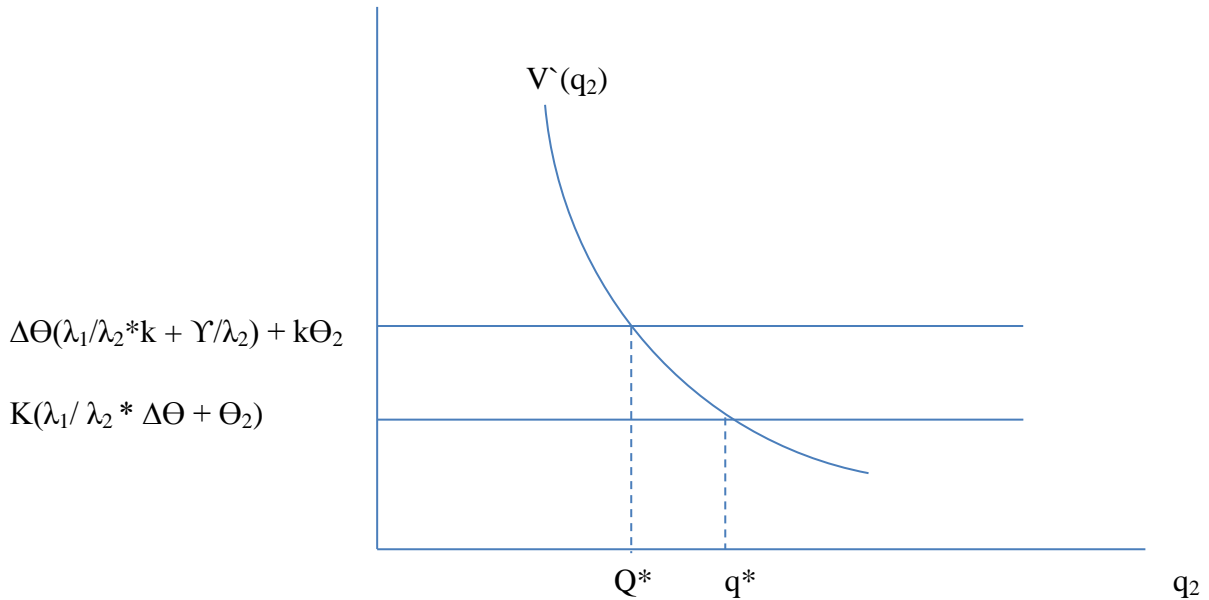


Fig. 2: The Optimal qualities of the dam constructed by the inefficient contractor.

As we can see from the graph, the quality of the dam constructed is higher under the condition in which the budget constrain doesn't bind than budget constrain binds ($q^* > Q^*$). Thus, whether the contractor is the efficient or the inefficient type, the expected value of the dam or the quality of the dam constructed is higher under the condition the budget constrain doesn't bind.

We summarize the effects of budget allocation on the expected value of the dam in the following proposition.

Proposition 1: *If the budget constraint is not binding, the bureaucrat offers a separating contract. In this case it is only the motivation of the bureaucrat that matters to implement the second best private procurement contract and the expected value of the dam is greater for contract offered by bureaucrat than the contract offered by the private manager. On the other hand if the budget constraint is binding, the bureaucrat offers either the separating or pooling contract depending on the values of k and Υ .*

4 The Politician Problem

The objective of the politician is to maximize its payoff function, $P(q)$ stated in section 2 above. This is possible either by higher expected value of the dam ($\lambda_1 V(q_1) + \lambda_2 V(q_2)$) or lower budget, B . As we presented in proposition one the expected value of the dam, ($\lambda_1 V(q_1) + \lambda_2 V(q_2)$), depends on the budget level and the motivation level of the bureaucrat. The motivation level of the bureaucrat is out of control of the politician. However, the politician can play with the budget level given the motivation level of the bureaucrat. In other word given the motivation level of the bureaucrat, the politician can anticipate the expected optimal value of the dam and so that determines the budget allocated to the bureaucrat. Thus, in this section we will see how the politician determines the budget allocated to the bureaucrat anticipating the expected optimal value of the dam from the contract offered by her.

The politician chooses the size of budget B given the motivation level of the bureaucrat, k . Starting from the extreme value of k , i.e $k = 1$ and assuming that the budget is not binding ($B > t_1$), we can see from (3) and (4) that the bureaucrat can provide the same expected value of the dam as the private procurement outcome and at the same time she has also a larger unspent budget. However, the politician doesn't prefer this excess budget and so either it reduces the budget to the lowest possible level or fully control the bureaucrat by offering a contract directly to the contractor. If the politician would contract directly with the contractor it must give a fixed budget to him. Thus, the politician is not able to save money when the cost is high and the expected value of the dam is low. In this case, the expected payoff the politician is lower as compared to its payoff from the contract offered by the bureaucrat. In other word, the politician's marginal cost of the contract it offers through a fixed budget is larger than the bureaucrat's marginal cost of the contract she offers through a contingent transfer. This implies that the bureaucrat would produce more than what the politician expect

if she is access to unlimited budget. Therefore, since the politician has a room to reduce the budget allocated to the bureaucrat without distorting the expected value of the dam as compared to the private procurement outcome, it wants to allocate smaller budget to the bureaucrat than the amount necessary to implement the private procurement outcome.

For $k < 1$ and if the budget is not binding, from (3) and (4) we can observe that the bureaucrat would even over produce relative to the case where $k = 1$. In this case, bureaucrat has a stronger preference for the expected value of the dam. It a gain implies that the politician allocates her a smaller budget so as to enjoy higher payoff.

This is the indirect way the politician control the bureaucrat with out affecting the expected value of the dam relative to the outcome of the private firms. As we observe from the right hand side objective function of the bureaucrat and the objective function of the politician, reducing budget has a direct effect of decreasing the excess budget of the bureaucrat and increasing the payoff the politician.

Lower k ($k < 1$) insures the politician that the expected value of the dam is higher than what it expected. Thus, in this case the best response of the politician is to lower the level of budget allocated to the bureaucrat. Again under the circumstance when k takes its critical values, $k = 1$ the contract offered by the bureaucrat gives a higher expected value of the dam relative to the contract offered by the politician. Thus, anticipating the higher value of the dam than what it expected, the politician best response is to reduce the budget allocated to the bureaucrat.

Here, whether the bureaucrat is motivated or less motivated the budget allocated to her is fixed and should be low as much as possible. This implies that, the budget allocation from the politician is less sensitive to the motivation of the bureaucrat or the budget can be seen as depending very little on the bureaucrat's actual performance.

Extension of the Model

In this part of the paper I extend the politician problem to the case in which the politician exercises direct control on the bureaucrat by relaxing the major assumption in the above sections (i.e the politician doesn't exercise direct control on the bureaucrat). Introducing direct control by the politician, I will show that control can reduce the excess budget and shift resources from the budget drift goal of the bureaucrat to a better expected value of the dam. I will also extend the politician problem to the case in which it cares for the pollution effects the construction of the dam causes on the society.

5 Direct Controls by the Politician

So far, we assumed that the politician has no direct control over the bureaucrat as it cannot observe the quality of the dam constructed or the unspent budget. Suppose now that the politician can control over how the budget is spent and increase its effective utilization. Tighter Control by the politician makes it difficult for the bureaucrat to divert funds from the construction of the dam which is the politician's main mission.

I will show that under complete information about the motivation level of the bureaucrat, tighter control allows the politician to increase the expected value of the dam and offer larger budgets to the bureaucrat. This raises the potential issue of bureaucrats claiming to be more motivated than they are in order to obtain larger budget, which I will analyze by modeling asymmetric information about the bureaucrat's motivation, denoted by k . I will also show how control by the politician can use as screening device to offer different budgets and exert different control intensities on bureaucrats with different level of motivation.

I model the politician's direct control in a simple way by assuming that it reduces the values attached to unspent budget by the bureaucrat. As we can see from section three, bureaucrat provides a higher expected value of the dam than the private manager or private firms even under the circumstance she involves in a massive amount of excess budget. Thus, the politician exercises direct control on bureaucrat by assuming that control reduces the value of unspent budget. In simple word, the main mission of exercising direct control is to reduce the amount of unspent budget.

If the politician exerts control with intensity $p \in [0, 1]$, the bureaucrat relative value of excess budget is given by $k(1 - p)$. Controlling has a cost to the politician and this cost is given

by an increasing and convex function, $m(p)$. Assuming that the politician can commit to the control intensity, the bureaucrat's objective function is now given as:

$$U = [\lambda_1 V(q_1) + \lambda_2 V(q_2)] + k(1-p)(B - \lambda_1 t_1 - \lambda_2 t_2).$$

Notice that the main difference between this function and the objective function of the bureaucrat discussed in section 3 is that this function contains the new parameter p .

If the politician doesn't exert a direct control on the bureaucrat (which implies $p = 0$), our previous model of the bureaucrat discussed in section 3 applies i.e U becomes $[\lambda_1 V(q_1) + \lambda_2 V(q_2)] + k(B - \lambda_1 t_1 - \lambda_2 t_2)$. If it could control with intensity 1, it would be impossible for the bureaucrat to benefit from unspent budget and U become reduces to $[\lambda_1 V(q_1) + \lambda_2 V(q_2)]$ i.e bureaucrat involves only in maximizing the expected value of the dam.

Given B and p , the bureaucrat solves, $U = [\lambda_1 V(q_1) + \lambda_2 V(q_2)] + k(1-p)(B - \lambda_1 t_1 - \lambda_2 t_2)$ subjected to the same (IC_i) and (IR_i) constraints as before and determines the optimal qualities and transfers for the contractor, $q(B, k(1-p))$, $t(B, k(1-p))$ and her indirect utility can be presented as $U(B, k(1-p))$.

Solving this problem and compare the result with the case when politician doesn't control the bureaucrat, direct control by the politician reduces the excess budget and resulted in higher expected value of the dam. The problem of the bureaucrat under the case in which the politician directly control her can be presented as,

$\max [\lambda_1 V(q_1) + \lambda_2 V(q_2)] + k(1-p)(B - \lambda_1 t_1 - \lambda_2 t_2)$, subjected to (IR_2) , (IC_1) , (BG_1) and (M) . Substituting t_1 and t_2 using the binding (IR_2) and (IC_1) , we can write the Lagrange as follows:

$L = \lambda_1 V(q_1) + \lambda_2 V(q_2) + k(1-p)(B - \lambda_1(\Theta_1 q_1 + \Delta \Theta q_2) - \lambda_2 \Theta_2 q_2) + \Upsilon(B - (\Theta_1 q_1 + \Delta \Theta q_2) + \mu(q_1 - q_2)$. Where, $\Upsilon > 0$ and $\mu > 0$ are the Lagrange multipliers for (BG_1) and (M) constraints respectively. The two first order conditions with respect to the qualities are:

$$\text{W.r.t } q_1: \lambda_1 V'(q_1) - k(1-p) \lambda_1 \Theta_1 - \Upsilon \Theta_1 + \mu = 0.$$

$\text{W.r.t } q_2: \lambda_2 V'(q_2) - k(1-p) \lambda_1 \Delta \Theta - k \lambda_2 \Theta_2 - \Upsilon \Delta \Theta - \mu = 0$. Rearranging the conditions, the results can be presented as,

$$V'(q_1) = \Theta_1(k(1-p) + \Upsilon/\lambda_1) - \mu/\lambda_1 \quad \text{--- (5)}$$

$$V'(q_2) = k\Theta_2 + \mu/\lambda_2 + \Delta\Theta(\lambda_1/\lambda_2 * k(1-p) + \Upsilon/\lambda_2) \quad \text{--- (6)}$$

The optimal expected values (1) and (5), (2) and (6) are quite similar except that the effective k is now $k(1-p)$ which is obviously lower than k for $p \neq 0$. Thus, the expected value of the dam is higher in the case when the politician exercises direct control over the bureaucrat than under the case it doesn't control the bureaucrat.

Even though the politician exercises direct control to lower the value the bureaucrat attaches to unspent budget, as we can see from (5) and (6), this leads to more resources being spent on constructing the dam given any budget. Thus, if the politician can control budget expenditures, it will offer the bureaucrat a larger budget and the bureaucrat will respond by offering a contract that provides a higher expected value of the dam. In other word, a lower k implies a higher budget. This is possible in the following ways. Recall that the politician allocates the fixed budget to maximizes its expected net benefit, $\lambda_1 V(q_1) + \lambda_2 V(q_2) - B$. The politician anticipates that bureaucrat that resist the politician budget offers in the name of offering higher incentive to the contractor have a higher k values. The politician knows that, the bureaucrat does so to engage in policy drift (by increasing the amount of unspent budget), which comes at the cost of a lower expected value of the dam. Therefore, for higher values of k , the politician curtails the bureaucrat's ability to engage in policy drift by lowering the budget.

The overall effects of the politician direct control as compared to the case that it doesn't control the bureaucrat are presented in the following proposition.

Proposition 2: *direct control by the politician reduces the level of k , reduces the excess budget of the bureaucrat and so that provides higher expected value of the dam as compared to the case the politician doesn't control the bureaucrat.*

The politician will exert direct control (i.e chooses p). Given p , it is easy to prove that the effective k , $k(1-p)$ still increase with k . Since a higher effective k implies that the allocation of a lower budget to the bureaucrat, the less motivated bureaucrat, bureaucrat with higher k , will receive a smaller budget. This observation leads us to explore the possibility that a bureaucrat may have an incentive to over-state her degree of motivation in attempt to secure a larger budget. This is the same as to say, the bureaucrat with higher effective k tempts to act as if they have lower effective k .

Taking the above stated adverse selection problem in to consideration, I explore the politician problem by introducing asymmetric information about k . I will show that

asymmetric information about k makes budget allocation less sensitive to the bureaucrat's type.

Now let us solve the politician direct control problem by introducing asymmetric information about k . In contrast to the above values of k , the k I introduce in asymmetric information case is discrete and takes two values, $\{k_1, k_2\}$. The bureaucrat knows her own type $k \in \{k_1, k_2\}$ with $k_2 > k_1 > 0$, while the politician just believes that the probability of k_i is π_i where $i \in \{1, 2\}$, and $\pi_1 + \pi_2 = 1$.

If there was no scope for direct control as in section 3, the politician would have no screening instrument and it would have to offer the same budget to all types of bureaucrat. On the other hand as I explore it here, if the politician can control the bureaucrat it can allocate different amounts of budget with different control intensities to ensure incentive compatibility for each type of bureaucrat. Thus, the contract design by the politician to the bureaucrat is given by the menu, $\{B_i, p_i\}$ for $i = 1, 2$.

Before solving the politician direct control problem under asymmetric information about k , let start to solve the control problem under complete information about k . Under complete information about k the politician exercises direct control on the bureaucrat so as to maximize the net expected value of the dam without any constraint. The reason is that, as a worker in the public offices, the bureaucrat is already on duty which implies the only constraint under complete information, the participation constraint is satisfied.

Thus, under asymmetric information, the politician solves the following maximization problem:

$\max \lambda_1 V(q_1) - B_1 - m(p_1) + \lambda_2 V(q_2) - B_2 - m(p_2)$. Representing the expected value of the dam, $\lambda_1 V(q_1)$ by X_1 and $\lambda_2 V(q_2)$ by X_2 . Then, the maximization problem can be rewrite as,

$\max X_1 - B_1 - m(p_1) + X_2 - B_2 - m(p_2)$. The first order conditions with respect to B_1 and B_2 respectively are,

$$\partial X_1 / \partial B_1 = 1,$$

$$\partial X_2 / \partial B_2 = 1,$$

and the first order conditions with respect to p_1 and p_2 respectively are,

$$\partial X_1 / \partial p_1 = m'(p_1),$$

$$\partial X_2 / \partial p_2 = m'(p_2).$$

Having the above results for complete information case, I am now going to solve the politician problem under asymmetric information about bureaucrat's type. Since only the less motivated bureaucrat will have an incentive to claim to be motivated, the politician's contract under asymmetric information about k should satisfy the following incentive constraint for the bureaucrat: $k_2(1 - p_2)[B_2 - \lambda_2 t_2] \geq k_2(1 - p_1)[B_1 - \lambda_1 t_1]$. With the incentive to mimic the motivated bureaucrat, the less motivated bureaucrat incentive should be derived from her policy drift objective and should be satisfied for the screening mechanism to work. If the incentive constraint is binding, the politician reduces p_2 and increases B_2 or increases p_1 and decreases B_1 for the incentive constraint to satisfy. Then, with the participation constraint already satisfied, the politician solves the following maximization problem subjected to the incentive constraint:

$$\max \pi_1(\lambda_1 V(q_1) - B_1 - m(p_1)) + \pi_2(\lambda_2 V(q_2) - B_2 - m(p_2)), \text{ Subjected to } k_2(1 - p_2)[B_2 - \lambda_2 t_2] \geq k_2(1 - p_1)[B_1 - \lambda_1 t_1].$$

Representing $\lambda_1 V(q_1)$ by X_1 and $\lambda_2 V(q_2)$ by X_2 and Setting the Lagrange for the above problem,

$$L = \pi_1(X_1 - B_1 - m(p_1)) + \pi_2(X_2 - B_2 - m(p_2)) + \sigma[k_2(1 - p_2)(B_2 - \lambda_2 t_2) - k_2(1 - p_1)(B_1 - \lambda_1 t_1)].$$

Where, $\sigma > 0$ is the Lagrange multiplier for the incentive compatibility constraint of less motivated bureaucrat. The first order conditions with respect to the budgets are,

$$\partial L / \partial B_1 = \pi_1[\partial X_1 / \partial B_1 - 1] + \sigma(-k_2 + k_2(\partial p_1 / \partial B_1 + p_1)) = 0.$$

$$\partial L / \partial B_2 = \pi_2[\partial X_2 / \partial B_2 - 1] + \sigma(k_2 - k_2(\partial p_2 / \partial B_2 + p_2)) = 0. \text{ Rearranging the conditions we have,}$$

$$\partial X_1 / \partial B_1 = 1 + \sigma k_2 / \pi_1 * (1 - (\partial p_1 / \partial B_1 + p_1)) \text{ --- (7). Where, } \partial p_1 / \partial B_1 + p_1 \leq 1$$

$$\partial X_2 / \partial B_2 = 1 + \sigma k_2 / \pi_2 * ((\partial p_2 / \partial B_2 + p_2) - 1) \text{ --- (8). Where, } \partial p_2 / \partial B_2 + p_2 \leq 1$$

Comparing (7) and (8) with the results we found under complete information about k , a one unit increase in budget, increases the expected value of the dam by $\sigma k_2 / \pi_1 * (1 - (\partial p_1 / \partial B_1 + p_1))$ unit for motivated bureaucrat and decreases by $\sigma k_2 / \pi_2 * ((\partial p_2 / \partial B_2 + p_2) - 1)$ unit for less motivated bureaucrat. As I showed in section 4, if the bureaucrat offers a contract that yields a higher expected value than what the politician expected, the best response by the politician is to reduce the budget allocated for the bureaucrat. By the same reason for a one unit increase

in budget, since the motivated bureaucrat's expected value of the dam is above the expected value of the dam in the case of complete information, the best response by the politician is to reduce the budget level of the motivated bureaucrat as compared to the complete information case. On the other hand, since the less motivated bureaucrat's expected value of the dam is lower as compared to the complete information case, the best response by the politician is to increase the budget level in order to increase the expected value of the dam.

The asymmetric information consolidate with the bureaucrat type, helps the less motivated bureaucrat to have excess budget which she involves in her policy drift objective. This facts can also state as, motivated bureaucrat uses most of her additional budget for maximizing the expected value of the dam while the less motivated bureaucrat use this budget for her policy drift objective at the cost of providing lower expected value of the dam. If the politician can fully control the bureaucrats (the case where $\partial p_1 / \partial B_1 + p_1 = 1$ and $\partial p_2 / \partial B_2 + p_2 = 1$ in (7) and (8) respectively), the results we find in (7) and (8) are identical to the complete information case.

The first order condition with respect to the control intensities are:

$\partial L / \partial p_1 = \pi_1 (\partial X_1 / \partial p_1 - m'(p_1)) + \sigma (-k_2 + \partial (B_1 - \lambda_1 t_1) / \partial p_1) = 0$. Where, $\partial (B_1 - \lambda_1 t_1) / \partial p_1 \leq 0$.
 $\partial L / \partial p_2 = \pi_2 (\partial X_2 / \partial p_2 - m'(p_2)) + \sigma (-k_2 + \partial (B_2 - \lambda_2 t_2) / \partial p_2) = 0$. Where, $\partial (B_2 - \lambda_2 t_2) / \partial p_2 \leq 0$.
Rearranging the results we have,

$$m'(p_1) = \partial X_1 / \partial p_1 + \sigma k_2 / \pi_1 - \sigma / \pi_1 * \partial (B_1 - \lambda_1 t_1) / \partial p_1 \quad \text{--- (9)}.$$

$$m'(p_2) = \partial X_2 / \partial p_2 - \sigma k_2 / \pi_2 + \sigma / \pi_2 * \partial (B_2 - \lambda_2 t_2) / \partial p_2 \quad \text{--- (10)}.$$

Comparing (9) and (10) with the complete information case, p_1 increases while p_2 decreases. The reason is that, to satisfy the incentive constraint of the less motivated bureaucrat, the politician should increases p_1 and decreases p_2 relative to the complete information case.

In general as compared to the complete information cases, asymmetric information about bureaucrat's type forces the politician to increase the budget and decreases the control intensity for the less motivated bureaucrat, decreases the budget and increases the control intensity for the motivated bureaucrat. This can be summarized in the following propositions as follows.

Proposition 3: *Asymmetric information about bureaucrat's type has the effect of increasing the budget and effective k for less motivated bureaucrat while decrease them for the more motivated bureaucrat.*

6 Centralized Contracts as a Means to Control the Bureaucrat

It is commonly known that the construction industries are the major source of pollution. The construction of the dam as elements of the construction industries has also major source of air, water and noise pollutions. As the agent to the society, the politician wants to attain the socially efficient and minimum level of pollution arises from the construction of the dam. For this to happen, the politician wants the dam to be constructed by the contractor with lower pollution cost. The contractor incurs a cost to reduce the damage the construction of the dam causes on the environment. I assume that the contractor takes some measures to prevent these pollution problems.

The main measures taken by the contractors to reduce the pollutions are: to prevent erosion and run off, minimize land disturbance and leave maximum vegetation cover, control dusts through fine water sprays used to dampen the site, screen the whole site to stop dust spreading or alternatively, place fine mesh screening close to the dust source, cover piles of building materials like cement, sand and other powders, regularly inspects for spillages and locate them where they will not be washed in to water ways or drainage areas, use non-toxic paints, solvents and other hazardous materials wherever possible, segregate, tightly cover and monitor toxic substances to prevent spills and possible site contamination, cover up and protect all drains on site, collect any waste water generated from site activities in settlement tanks, screen, discharge the clean water, and dispose of remaining sludge according to environmental regulations, use low Sulphur diesel oil in all vehicles and equipment engines and incorporate the latest specifications of particulate filters and catalytic converters, no burning of materials on site and reduce noise pollution through careful handling of materials, modern, quiet power tools, equipment and generators, low impact technologies, and wall structure as sound shields.

The above measures taken by the contractors to reduce air, water and noise pollutions are assumed to be included as parts of the quality of the dam and it costs the contractor β_i for $i = 1, 2$ per quality of the dam constructed. The constant β is private information of the contractor and it takes two values β_1 with probability α_1 and β_2 with probability α_2 and with $\Delta\beta = \beta_2 - \beta_1 > 0$ and $\alpha_1 + \alpha_2 = 1$. As we briefly present in section 2 and here also, β_1 is the marginal cost of

pollution of the efficient contractor and β_2 is the marginal cost of pollution of the inefficient contractor.

From the measures taken by the contractor, we can understand that internalizing the negative externalities arise from the construction of the dam is possible when the contract design by the bureaucrat incorporate this cost in to the transfer made to the contractor. This transfer should at least exceed the sum of the private cost and pollution cost incurred by the contractor. However, the key problem here is that the bureaucrat doesn't care for the pollution cost caused by the construction of the dam in designing her mechanism and do not want to include this concern in her objective function.

The main reason for the bureaucrat not prefers to internalize this cost is that she operates under a fixed budget allocated from the politician. From the bureaucrats objective function stated in section 2, we can see that bureaucrat has an objective of maximizing excess budget and this is possible if the budget allocated to her exceeds the contingent transfers she pays to the contractor. The contingent transfers to the contractor must at least greater than or equal to the sum of both the private and pollution costs (the social cost) if the bureaucrat is environmentalist and it must be greater than or equal to the private cost if the bureaucrat is not environmentalist. Since the social cost exceeds the private cost, the excess budget to the bureaucrat under the condition the bureaucrat is environmentalist is lower than under the condition in which she doesn't care for the environment.

Due to the above reason, bureaucrat doesn't prefer to design an incentive contract that enables the contractor to internalize the pollution cost. The contractor bears the pollution cost as far as the bureaucrat designs an incentive feasible menu of contract that considers and incorporated this cost. Since considering the pollution cost in designing the contract reduces the bureaucrat's payoff, the bureaucrat prefers to exclude this cost in designing a contract to the contractor. Thus, the contract designed and offered by the bureaucrat doesn't solve the pollution problem the construction of the dam imposes on the environment. Therefore, a conflicting of interests arises between the politician and the bureaucrat.

The politician wants to delegate designing and offering contract to its delegate, the bureaucrat so as to maximize the expected value of the dam with the efficient and lowest level of pollution. However, the contract design by the bureaucrat doesn't include the pollution cost for the reason that it decreases her payoff. Thus, the central idea of this section is to find out

the mechanism the politician use to control the bureaucrat and attain the socially efficient and minimum level of pollution arises from the construction of the dam.

Internalizing the pollution cost and including the marginal cost of pollution to the analysis, now the contractor can be of four possible types (low private cost, low pollution cost), (low private cost, high pollution cost), (high private cost, low pollution cost) and (high private cost, high pollution cost). The types are private information to the contractor and assumed to be independent. The alternative way to represent the above stated types with their respective probabilities are, (Θ_1, β_1) type with probability (λ_1, α_1) , (Θ_1, β_2) type with probability (λ_1, α_2) , (Θ_2, β_1) type with probability (λ_2, α_1) and (Θ_2, β_2) type with probability (λ_2, α_2) . Since we assume the independency of the types, we can multiply the probabilities and so that we have:

(Θ_1, β_1) type with probability $\lambda_1\alpha_1$,

(Θ_1, β_2) type with probability $\lambda_1\alpha_2$,

(Θ_2, β_1) type with probability $\lambda_2\alpha_1$ and

(Θ_2, β_2) type with probability $\lambda_2\alpha_2$ (with, $\lambda_1\alpha_1 + \lambda_1\alpha_2 + \lambda_2\alpha_1 + \lambda_2\alpha_2 = 1$).

The politician knows that the contractor can be of the above stated possible types. Knowing this, the politician can design an incentive feasible menu of contract that satisfies the incentive and participation constraint of each type and gives it to the bureaucrat to be implemented. Let call this contract the centralized contract to identify it from delegation contract. In delegation contract, it is the bureaucrat who designs and offer contract to the contractor.

The main idea of the centralized contract is that instead the politician delegates the task of mechanism design to the bureaucrat; it designs the contract and gives it to the bureaucrat. The bureaucrat is now acts as a monitor to organize the construction work of the dam. In centralized contract, the politician doesn't delegate the task of mechanism design to the bureaucrat. This implies that no budget allocation to the bureaucrat and the task of mechanism design are overtaken by the politician. Assuming that a constant β represents the cost of pollution the construction of the dam imposes on the society; q_3, q_4, q_5 and q_6 are the qualities of the dam constructed by the above contractor's type respectively and t_3, t_4, t_5 and t_6 are their respective contingent transfers, then the politician solves problem;

$$P_1(q) = \lambda_1\alpha_1(V(q_3) - t_3) + \lambda_1\alpha_2(V(q_4) - t_4) + \lambda_2\alpha_1(V(q_5) - t_5) + \lambda_2\alpha_2(V(q_6) - t_6) - \beta.$$

Where λ_1 and λ_2 are the probabilities that the contractor is efficient and inefficient type respectively, $V(q)$ is the values the quality of the dam gives to the politician. It is concave and increasing function of q ; α_1 and α_2 are the probabilities that the contractor has low marginal cost of pollution and high marginal cost of pollution respectively.

Even if “centralized contract” is totally different from the “delegation contract”, in this section I raise the issue of centralized contract as the means of controlling the bureaucrat. Assuming that the bureaucrat or the monitor in this case can (1) observe the quality of the dam freely (2) report it truthfully to the politician, the politician can implement the second best contract. In applying the centralized contract as a means to control a bureaucrat, the previous assumptions the politician has no time, knowledge or license to design the contract by it self are relaxed. In the centralized contract as a controlling instrument used by politician, the politician designs an incentive feasible contract (that satisfies the incentive and participation constraints of the contractor) and gives it to the bureaucrat or to the monitor to be implemented.

Before we solve the above problem, let start to solve from the simple one by assuming that the politician doesn't consider the pollution cost arises from the construction of the dam in setting its objectives. This is the case when $\beta = 0$ in $P_1(q)$. We use this case as the benchmark of the complex model stated above. Thus, the benchmark model (the case when the politician doesn't consider the pollution impacts the construction of the dam imposes on the society) is similar to the contract offered by private firms. In this benchmark case, the objective function of the politician is only restricted to maximize the expected value of the dam and the cost to the contractor is only the private cost. This is the same as to say the politician solves $P_1(q)$ given that $\beta = 0$ and the contractor can be of two possible type, subjected to the same (IC_i) and (IR_i) constraints stated in section 3. In this set up, the contractor can be the efficient (Θ_1) or the inefficient (Θ_2) types.

The main reason to set up the benchmark model in this section is to simplify the analysis of the centralized contract and moreover to use it for comparative measures for the results we will compute in centralized contract by including the pollution cost.

If the pollution impact of the construction of the dam doesn't internalize, then the contractor doesn't incur the pollution cost and so that the types of the contractor is determined only by his private cost. As we stated it above, in this case the contractor is of two possible types: the efficient and the inefficient. The politician also knows this. Thus, for each type, the

politician designs incentive feasible menus of contract and gives it to the bureaucrat who is now monitoring the construction works of the dam. Generally, in this case the benchmark model is reduced to the private procurement contract type analyzed by Laffont and Martimort (2002). Now, both the politician and the bureaucrat solve the following maximization problem:

$\max [\lambda_1 V(q_1) + \lambda_2 V(q_2)] - (\lambda_1 t_1 + \lambda_2 t_2)$, Subjected to (IC_i) and (IR_i) . Where λ_1 and λ_2 are the probabilities that the contractor is the efficient (Θ_1) and the inefficient (Θ_2) types respectively, $V(q)$ is the values the qualities of the dam give to the societies and it is a concave and increasing function of q , t_1 and t_2 are the contingent transfer to the efficient and the inefficient contractors respectively.

The results we can find here are the same as the second best private procurement contract analyzed by Laffont and Martimort (2002) and these results are presented in section 2 under sub section 2.4 for the private procurement contract (PP). I use these results as the benchmark for the centralized contract I analyze next by including the pollution cost.

The politician employs the centralized contract to control the bureaucrat. This contract as a controlling instrument is used in the scenario the politician intends to internalize the environmental impacts the construction of the dam imposes on the societies. The politician uses this contract to attain the minimum and efficient level of pollution. Delegation contract doesn't solve this problem for the reason stated above that the bureaucrat doesn't want to include this cost in designing a contract.

The centralized contract employed by the politician forced the bureaucrat to have the same objective function as the politician. From the above stated benchmark, we can see that this contract makes both the politician and the bureaucrat to solve the private procurement problem analyzed above. However, in the case of delegation and the politician is not environmentalist, the controlling method applied is used for the purpose of shift the budget from the budget drift objective of the bureaucrat to maximize the expected value of the dam. In other word, the bureaucrat solves $U(k, B, q)$ and the controlling mechanism applied by the politician is the one mentioned in section 5.1 of this paper.

Having the above benchmark results, now I extend the model to the more complex one by incorporating the pollution cost arises from the construction of the dam in to the objective function of the politician.

To see how the centralized contract can be computed and used as a means to control the bureaucrat, I employ the technique used in Laffont and Martimort (2002; 86). Laffont and Martimort design an incentive feasible contract for the case in which the agents are more than two types and they analyzed the case with three types of agents. In my case, as we can observe from the objective function of the politician and listed them above the contractor can be of four possible types. The first possible type is low private marginal cost (Θ_1) and low marginal cost of pollution (β_1) and we can call this contractor the most efficient contractor. The second possible type is low private marginal cost (Θ_1) and high marginal cost of pollution (β_2) and we call this contractor the second most efficient contractor. The third possible type is high private marginal cost (Θ_2) and low marginal cost of pollution (β_1) and this contractor is the third efficient contractor. The last and the fourth possible type is high private marginal cost (Θ_2) and high marginal cost of pollution (β_2) and we call this contractor the least efficient or inefficient contractor.

The direct controlling technique we discussed in section 5.1 is only useful to screen out the motivated bureaucrat. The politician employed this controlling technique to shift unspent budget from budget drift objective of the bureaucrat and so that maximizes the expected value of the dam. However, in this section in addition to maximize the expected value of the dam, the politician has the objective of attain the minimum and efficient pollution level caused by the construction of the dam. Even if the bureaucrat is an agent to the politician, both possible types, motivated type and less motivated type, have no any concern for the pollution level targeted by the politician. Thus, the previous controlling method does not solve this social problem, pollution problem. Therefore, that is the main reason here to employ the centralized contract as a means to control the bureaucrat.

To simplify the model I assume that, the types are independent and $\Theta_2 - \Theta_1 = \beta_2 - \beta_1 = \Delta\Theta = \Delta\beta$.

We denote the truthful direct revelation mechanism in these four types environment by $\{(t_3, q_3); (t_4, q_4); (t_5, q_5); (t_6, q_6)\}$. Using similar notation information rents for each type of contractors respectively are,

$$U_3 = t_3 - \Theta_1 q_3 - \beta_1 q_3;$$

$$U_4 = t_4 - \Theta_1 q_4 - \beta_2 q_4;$$

$$U_5 = t_5 - \Theta_2 q_5 - \beta_1 q_5; \text{ and}$$

$$U_6 = t_6 - \Theta_2 q_6 - \beta_2 q_6.$$

Where U_3 , U_4 , U_5 and U_6 are information rent for type (Θ_1, β_1) , type (Θ_1, β_2) , type (Θ_2, β_1) and type (Θ_2, β_2) contractors respectively, t_3 , t_4 , t_5 and t_6 are the contingent transfers to type (Θ_1, β_1) , type (Θ_1, β_2) , type (Θ_2, β_1) and type (Θ_2, β_2) contractor respectively and q_3 , q_4 , q_5 and q_6 are the qualities of the dam constructed by type (Θ_1, β_1) , type (Θ_1, β_2) , type (Θ_2, β_1) and type (Θ_2, β_2) contractor respectively.

For each of the four possible types, we now have the following incentive constraints:

For the most efficient type, (Θ_1, β_1) .

$$t_3 - \Theta_1 q_3 - \beta_1 q_3 \geq t_4 - \Theta_1 q_4 - \beta_1 q_4$$

$$U_3 \geq U_4 + \Delta\beta q_4 \text{ ----- (11)}$$

This incentive constraint binds the most efficient type not to take the contract designs for the second efficient type.

The second incentive constraint of the most efficient type is,

$$t_3 - \Theta_1 q_3 - \beta_1 q_3 \geq t_5 - \Theta_1 q_5 - \beta_1 q_5,$$

$$U_3 \geq U_5 + \Delta\Theta q_5 \text{ --- (12)}$$

This incentive constraint binds the most efficient type not to take the menu of contract design for the third efficient contractor.

The last incentive constraint of the efficient contractor is,

$$t_3 - \Theta_1 q_3 - \beta_1 q_3 \geq t_6 - \Theta_1 q_6 - \beta_1 q_6$$

$$U_3 \geq U_6 + \Delta\Theta q_6 + \Delta\beta\Delta\beta \text{ --- (13)}$$

Again this incentive constraint binds (Θ_1, β_1) type contractor not to take the menu of contract designs for type (Θ_2, β_2) contractor.

For the second efficient type, (Θ_1, β_2) , the incentive constraints are:

$$t_4 - \Theta_1 q_4 - \beta_2 q_4 \geq t_5 - \Theta_1 q_5 - \beta_2 q_5$$

$$U_4 \geq U_5 + \Delta\Theta q_5 - \Delta\beta q_5 \text{ ----(14)}$$

This incentive constraint binds the (Θ_1, β_2) type contractor not take the contract designs for the (Θ_2, β_1) type contractor.

$$t_4 - \Theta_1 q_4 - \beta_2 q_4 \geq t_6 - \Theta_1 q_6 - \beta_2 q_6$$

$$U_4 \geq U_6 + \Delta\beta q_6 + \Delta\Theta q_6 \text{ -----(15)}$$

This incentive constraint binds the (Θ_1, β_2) type contractor not to take the menu of contract designs for (Θ_2, β_2) type contractor.

$$t_4 - \Theta_1 q_4 - \beta_2 q_4 \geq t_3 - \Theta_1 q_3 - \beta_2 q_3$$

$$U_4 \geq U_3 - \Delta\beta q_3 \text{ ---- (16)}$$

This is the incentive constraint that binds (Θ_1, β_2) type contractor not to take the menu of contract designs for the most efficient contractor.

For the third efficient type, (Θ_2, β_1) the incentive constraints are:

$$t_5 - \Theta_2 q_5 - \beta_1 q_5 \geq t_6 - \Theta_2 q_6 - \beta_1 q_6$$

$$U_5 \geq U_6 + \Delta\beta q_6 \text{ ---- (17)}$$

This is the incentive constraint that binds (Θ_2, β_1) type contractor not to take the menu of contract design for the least efficient contractor.

$$t_5 - \Theta_2 q_5 - \beta_1 q_5 \geq t_4 - \Theta_2 q_4 - \beta_1 q_4$$

$$U_5 \geq U_4 + \Delta\beta q_4 - \Delta\Theta q_4 \text{ ----(18)}$$

This is the incentive constraint that binds the (Θ_2, β_1) type contractor not to take the menu of contract design for (Θ_1, β_2) type contractor.

$$t_5 - \Theta_2 q_5 - \beta_1 q_5 \geq t_3 - \Theta_2 q_3 - \beta_1 q_3$$

$$U_5 \geq U_3 - \Delta\Theta q_3 \text{ -----(19)}$$

This is the incentive constraint that prevent the (Θ_2, β_1) type contractor not to take the contract design for the most efficient contractor.

For the least efficient type, (Θ_2, β_2) type, the incentive constraints are:

$$t_6 - \Theta_2 q_6 - \beta_2 q_6 \geq t_5 - \Theta_2 q_5 - \beta_2 q_5$$

$$U_6 \geq U_5 - \Delta\beta q_5 \text{ -----(20)}$$

This constraint binds the least efficient contractor not to take the contract design for (Θ_2, β_1) type contractor.

$$t_6 - \Theta_2 q_6 - \beta_2 q_6 \geq t_4 - \Theta_1 q_4 - \beta_2 q_4$$

$$U_6 \geq U_4 - \Delta\Theta q_4 \text{ -----(21)}$$

This constraint prevent the least efficient contractor not to take the contract design for (Θ_1, β_2) type contractor.

$$t_6 - \Theta_2 q_6 - \beta_2 q_6 \geq t_3 - \Theta_1 q_3 - \beta_1 q_3$$

$$U_6 \geq U_3 - \Delta\Theta q_3 - \Delta\beta q_3 \text{ -----(22)}$$

This constraint binds the least efficient contractor not to take the menu of contract design for the most efficient contractor.

These incentive constraints from (11) to (22) can be classified as “local and “global” incentive constraints. Local incentive constraints involves adjacent types such as the upward incentive constraints (11), (12), (17) and the downward ward incentive constraints (16), (19), (20) and (21). Global incentive constraints involve non adjacent types such as upward incentive constraint (13) or downward incentive constraint (22).

To simplify the analysis and find the relevant binding constraints, intuition suggests that the more efficient type want to lie upward and claim they are less efficient. Therefore, we can ignore the downward incentive constraint (16), (19), (20), (21) and (22). Using monotonicity condition, the more efficient type construct higher quality of dam than the less efficient type and this is obvious from the first order condition of optimization. Thus, the following condition should be satisfied,

$$q_3 \geq q_4 \geq q_5 \geq q_6 \text{ -----(23)}$$

From this condition, (12) and (17) can imply the global incentive constraint (13). Constraints (11), (12), and (17) together can imply (15). The least efficient type participation constraint should also be satisfied.

$$U_6 \geq 0 \text{ -----(24)}$$

Thus, the relevant constraints are (11), (12), (17), (24) and (23).

Now once the politician designs this mechanism, it gives these menus of contract to the bureaucrat who is now monitoring the construction work of the dam. The bureaucrat can not modify the contract designed by the politician. If she tried; the politician can easily identify the changes on the contract. Thus, the only option to the bureaucrat is offering the contract designed by the politician and so that the objective stated by the politician (maximizing the expected value of the dam and minimizing the pollution cost arises from the construction of the dam) can be fully addressed.

As in Khalil and Kim (2011) concluded, centralization control or centralization contract achieves the second best optimum. My case also shows that “centralization control” achieves the second best optimum value of the dam.

Now it is obvious that in centralized contract the objective function of the bureaucrat and that of the politician are the same and this is the objective function that maximizes the value of the dam and as well as the objective function that solve the pollution problem arises from the construction of the dam. Assuming that the cost of pollution arises from the construction of the dam is represented by β , both the politician and the bureaucrat solves, $P_1(q)$, Subjected to (11), (12), (17), (24) and (23).

Representing the transfer paid as the information rent, both the politician and the bureaucrat will go to solve the following program:

Max $\lambda_1 \alpha_1 (V(q_3) - (\Theta_1 + \beta_1)q_3 - U_3) + \lambda_1 \alpha_2 (V(q_4) - (\Theta_1 + \beta_2)q_4 - U_4) + \lambda_2 \alpha_1 (V(q_5) - (\Theta_2 + \beta_1)q_5 - U_5) + \lambda_2 \alpha_2 (V(q_6) - (\Theta_2 + \beta_2)q_6 - U_6) - \beta$, Subjected to, (11), (12), (17), (24) and (23).

It should be clear that constraints (11), (12), (17) and (24) are all binding at the optimal contract. This leads to the following expression of the information rent,

$$U_3 = \Delta\beta q_6 + \Delta\Theta q_5,$$

$$U_4 = \Delta\beta(q_6 - q_4) + \Delta\Theta q_5,$$

$$U_5 = \Delta\beta q_6, \text{ and}$$

$$U_6 = 0.$$

Substituting the rents in the objective function, the politician and the bureaucrat solve the following problem:

$$\text{Max } \lambda_1 \alpha_1 (V(q_3) - (\Theta_1 + \beta_1)q_3 - \Delta\beta q_6 - \Delta\Theta q_5) + \lambda_1 \alpha_2 (V(q_4) - (\Theta_1 + \beta_2)q_4 - \Delta\beta (q_6 - q_4) - \Delta\Theta q_5) + \lambda_2 \alpha_1 (V(q_5) - (\Theta_2 + \beta_1)q_5 - \Delta\beta q_6) + \lambda_2 \alpha_2 (V(q_6) - (\Theta_2 + \beta_2)q_6) - \beta, \text{ Subjected to (23).}$$

Introducing the Lagrange problem, the politician and the bureaucrat solve:

$$L = \text{Max } \lambda_1 \alpha_1 (V(q_3) - (\Theta_1 + \beta_1)q_3 - \Delta\beta q_6 - \Delta\Theta q_5) + \lambda_1 \alpha_2 (V(q_4) - (\Theta_1 + \beta_2)q_4 - \Delta\beta (q_6 - q_4) - \Delta\Theta q_5) + \lambda_2 \alpha_1 (V(q_5) - (\Theta_2 + \beta_1)q_5 - \Delta\beta q_6) + \lambda_2 \alpha_2 (V(q_6) - (\Theta_2 + \beta_2)q_6) - \beta + \Upsilon_1 (q_3 - q_4) + \Upsilon_2 (q_4 - q_5) + \Upsilon_3 (q_5 - q_6)$$

Where, $\Upsilon_1 > 0$, $\Upsilon_2 > 0$ and $\Upsilon_3 > 0$ are the Lagrange multipliers. The first order condition with respect to q_3 , q_4 , q_5 , and q_6 respectively are,

$$\text{W.r.t } q_3: \lambda_1 \alpha_1 V'(q_3) - (\Theta_1 + \beta_1) + \Upsilon_1 = 0$$

$$\text{W.r.t } q_4: \lambda_1 \alpha_2 V'(q_4) - (\Theta_1 + \beta_2) + \Delta\beta - \Upsilon_1 + \Upsilon_2 = 0$$

$$\text{W.r.t } q_5: -\Delta\Theta - \Delta\Theta + \lambda_2 \alpha_1 V'(q_5) - (\Theta_2 + \beta_1) - \Upsilon_2 + \Upsilon_3 = 0$$

$$\text{W.r.t } q_6: -\Delta\beta - \Delta\beta - \Delta\beta + \lambda_2 \alpha_2 V'(q_6) - (\Theta_2 + \beta_2) - \Upsilon_3 = 0$$

Re-arranging the above first order condition,

$$V'(q_3) = (\Theta_1 + \beta_1) - \Upsilon_1 / \lambda_1 \alpha_1$$

$$V'(q_4) = (\Theta_1 + \beta_2) - \Delta\beta + \Upsilon_1 - \Upsilon_2 / \lambda_1 \alpha_2$$

$$V'(q_5) = (\Theta_2 + \beta_1) + \Upsilon_2 - \Upsilon_3 + 2\Delta\Theta / \lambda_2 \alpha_1$$

$$V'(q_6) = (\Theta_2 + \beta_2) + \Upsilon_3 + 3\Delta\beta / \lambda_2 \alpha_2.$$

Now, the expected value of the dam is lower as compared to the benchmark optimum level of the private procurement contract. This is due to the reason that the politician incorporates the external cost arises from the construction of the dam in to its objective function. It is obvious that internalize the external cost the construction of the dam imposes on the society reduces the pollution impacts on the societies, in fact at the expense of decreasing the expected value of the dam. The intuition behind this result is that the pollution cost internalized by the contractor increases his cost and higher cost implies lower expected value of the dam as compared to the benchmark case. In fact, the higher value of the dam is

generated in the benchmark model at the cost of polluting the environment. Thus, less polluted environment is possible at the cost of lower expected value of the dam constructed at the equilibrium.

Proposition 4: *Internalizing the external costs arises from the construction of the dam reduces the pollution costs on the environment at the expense of providing lower expected value of the dam as compared to the benchmark case.*

7 Conclusions

In this paper I consider a dam constructed by the politician that provides a benefit to the society. Assuming that the politician has no time or ability to perform the detail tasks of the construction of the dam, it delegates these tasks to its delegate (employee), the bureaucrat. The bureaucrat again delegates the construction works of the dam to the contractor. In this relationship, the politician is the funding authority, it allocates a fixed budget to the bureaucrat for the construction works to be undertaken and more over it accept the dam milestone and its completion.

Given the fixed budget, the bureaucrat designs an incentive feasible menu of contract to the contractor so as to maximize the expected value of the dam and the level of excess budget. The excess budget is the difference between the fixed budget allocated from the politician and the expected transfers to the contractor. Bureaucrat attaches different weights to excess budget depending on their level of motivation. We assume that, this weight can take a value between 0 and 1. Motivated bureaucrat attaches a lower weight to the excess budget while the less motivated bureaucrat attaches higher weight to the excess budget. Bureaucrat attaches higher weight to the excess budget construct lower quality dam relative to bureaucrat attaches lower weights. Thus, motivated bureaucrat provides a higher expected value of the dam than the less motivated one.

The motivation of the bureaucrat helps her to design a contract that provides a higher expected value of the dam than the private firm's contract. If bureaucrats are more motivated, the expected value of the dam for the contract designed by bureaucrat outperforms the contract designed by private firms. Thus, the major problem in the politician-bureaucrat relationship is due to the excess budget rather than the difference in the expected value of the dam.

So as to reduce the level of excess budget of the bureaucrat, the politician exercise direct control on the bureaucrat. Direct control by the politician reduces the level of excess budget and further increases the expected value of the dam relative to the case in which politician doesn't control the bureaucrat. Under the circumstance when the politician has no room to design an incentive feasible contract to the bureaucrat; the politician can allocate the same fixed budget to the bureaucrat so as to maximize the net expected value of the dam. But under asymmetric information about the bureaucrat's type and at the same time the politician have a chance to design an incentive feasible menu of contract to each type, the politician can control the bureaucrat by designing incentive mechanism.

The contracting elements in designing the contract to the bureaucrat are the budget allocated and the intensities of control. If the politician has complete information about the bureaucrat's type, it allocates a larger budget for motivated bureaucrat than less motivated one. Thus, this raises the potential problem that under asymmetric information about the bureaucrat's type, the less motivate bureaucrat has an incentive to overstate her level of motivation. Therefore, the politician contract should be designed in such a way that it satisfies the incentive constraint of the less motivated bureaucrat. This incentive protects the less motivate bureaucrat not to take the contract design for the motivated one. Asymmetric information about the motivation level of the bureaucrat has the effect of increases budget and decreases control level for less motivated bureaucrat and decreases the budget and increases the control intensities to the motivated bureaucrat.

In addition to maximizing the expected value of the dam, the politician has also the objective of minimizing the pollution impact the construction of the dam causes on the societies. To attain this objective, the politician reset its objective function so that it internalizes this cost. But the bureaucrat, whom the politician delegates the task of designing a contract to the contractor have no any concern for the effect on the environment caused by the construction of the dam. Reducing this cost is possible by designing a contract that considers this cost and as well as satisfies the incentive and participation constraints of the contractor. In this case, in addition to the private costs the contractor has also the pollution cost which incurs through the measures he takes to reduce the impact the construction of the dam causes on the environment.

To reduce this cost and attain the objective restated by the politician, the new incentives and participation constraints of the contractor should include the pollution costs in addition to

his private cost. Since the objective function of the bureaucrat do not set in such a way that it includes this cost in designing the new contract for the contractor, the objective of the lowest and efficient level of pollution could not be attained. Therefore, the politician should control the bureaucrat to internalize this cost and attain the minimum and efficient pollution level arises from the construction of the dam.

The politician uses the centralized contract to make the bureaucrat in line with the objective of attaining the minimum and efficient pollution level. The idea of centralized contract is that instead the politician delegate the task of contract design to the bureaucrat, the politician designs the contract by it self and gives it to the bureaucrat. The bureaucrat is now acts as a monitor, coordinating the construction works of the dam and offers the contract designed by the politician. In this circumstance both the politician and the bureaucrat solve the problem that internalized the pollution cost the construction of the dam causes on the environment. Thus, the objective of efficient pollution level attained.

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